

Q_{weak} Detector System (WBS 1)

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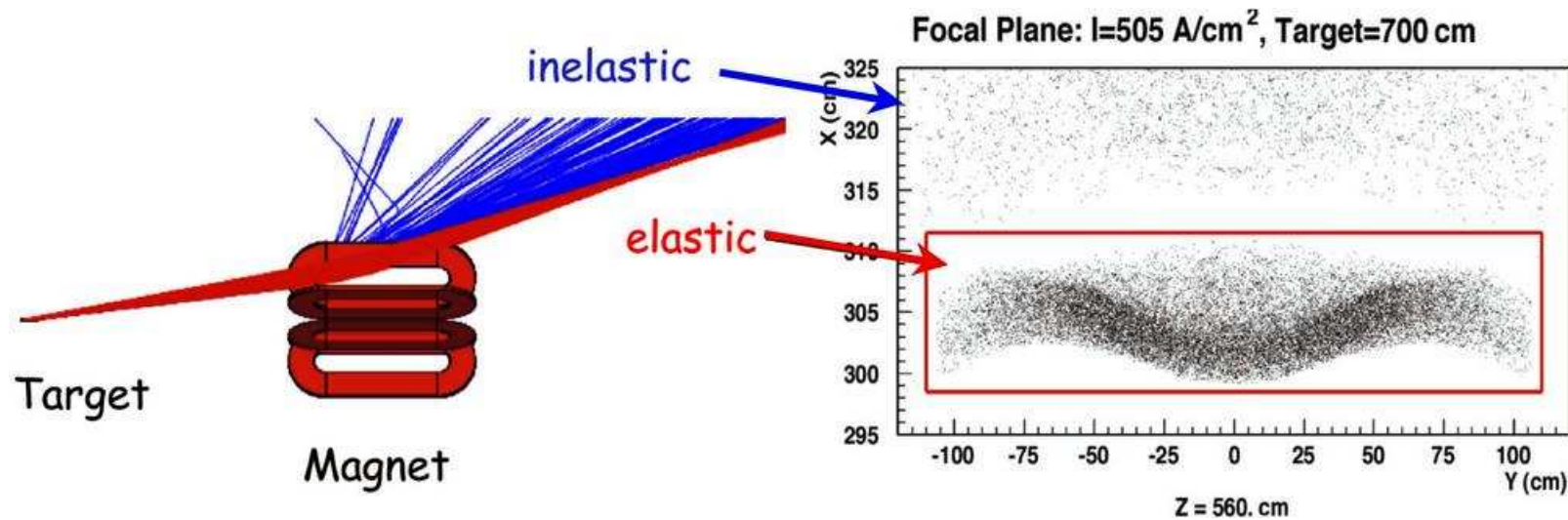
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Q_{weak} Spectrometer Optics and Toroidal Magnet

Q_{weak} spectrometer :
optics from GEANT simulation
provides clean elastic/inelastic electron separation at the focal plane



Q_{weak} toroidal magnet:
8 resistive toroidal coils with simple shape

location of detector active area
(red box)

Detector and Front End Electronics Requirements

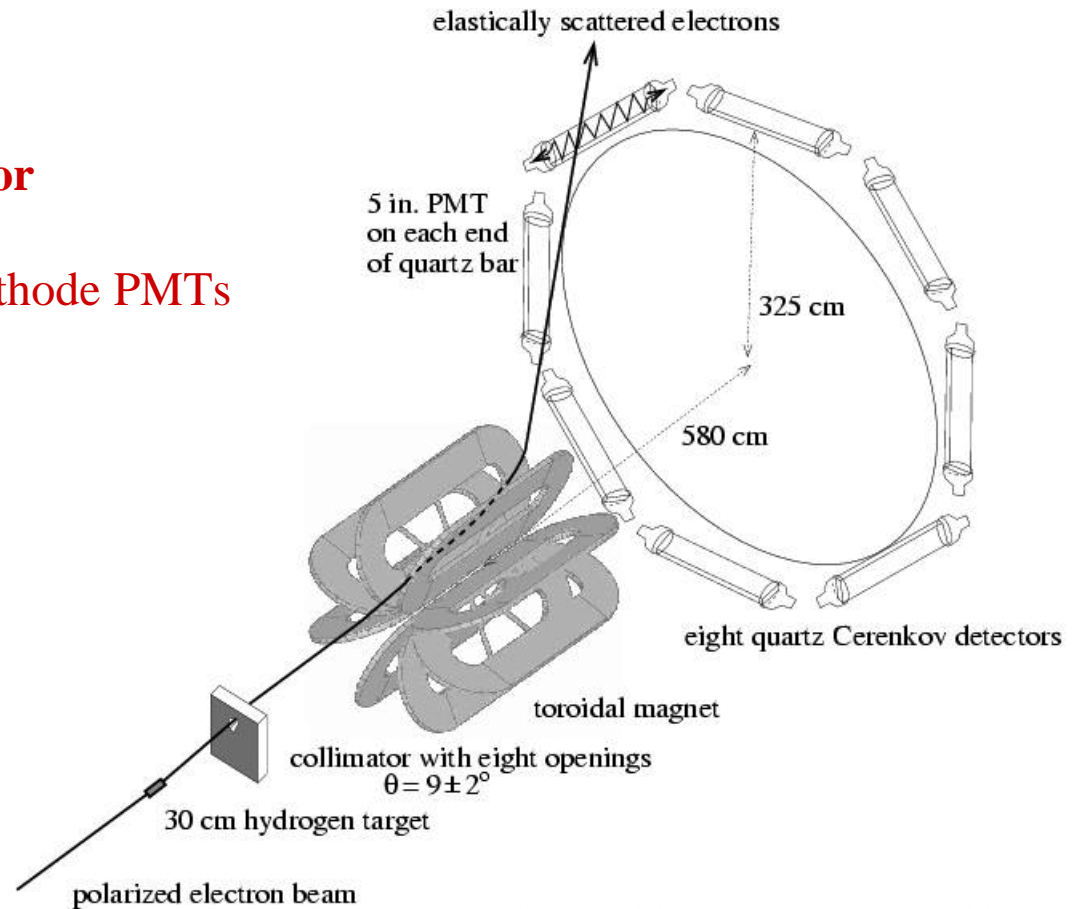
Focal plane detector requirements:

- Operation at counting statistics
- Uniformity of response and linearity
- Insensitivity to backgrounds: γ , n, π , p
(to avoid both dilution and false asymmetries)
- Radiation hardness (expect > 300 kRad)
- Operation in current and pulse mode
- Negligible electronic noise contribution

Current mode detection of elastically scattered e^- in eight synthetic quartz Cerenkov detectors

Synthetic Quartz Cerenkov Detector

12 cm x 200 cm x 2.5 cm quartz bars
read out at both ends by S20 photocathode PMTs
(expect ~ 100 pe/event)



Synthetic Quartz (fused silica)

index of refraction ~ 1.47 , angle of total internal reflection $= 43^\circ$

for $\beta=1$, Cerenkov angle is $\cos \theta = 1/\beta n = 47^\circ$

momentum threshold $= \frac{m}{\sqrt{n^2 - 1}}$ ($= 0.93 m$ for $n = 1.47$)

synthetic quartz is radiation hard at the few 100 krad level

polishing requirements: optical polish 25 Å rms

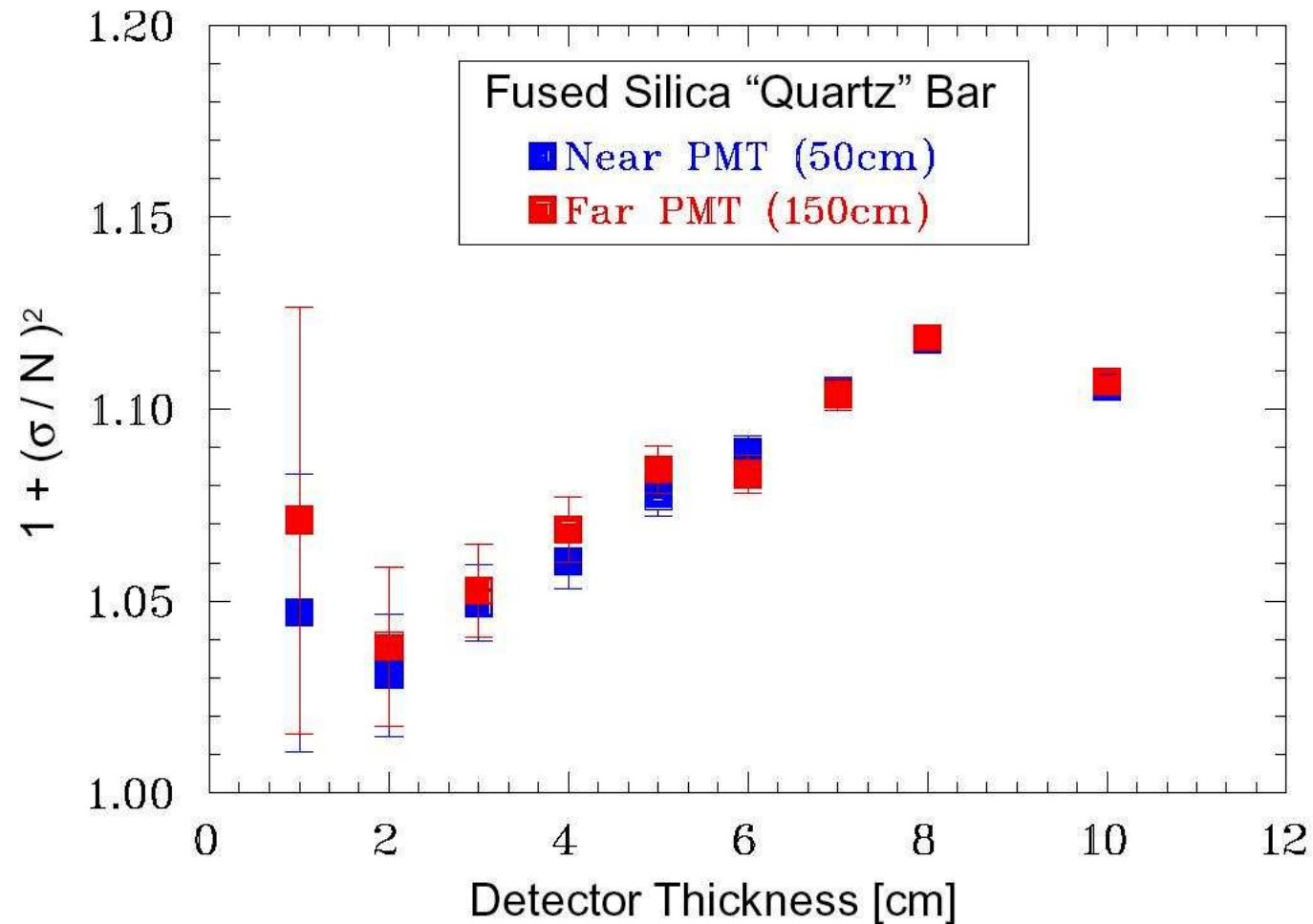
reflectivity 0.997

thin to minimize showering



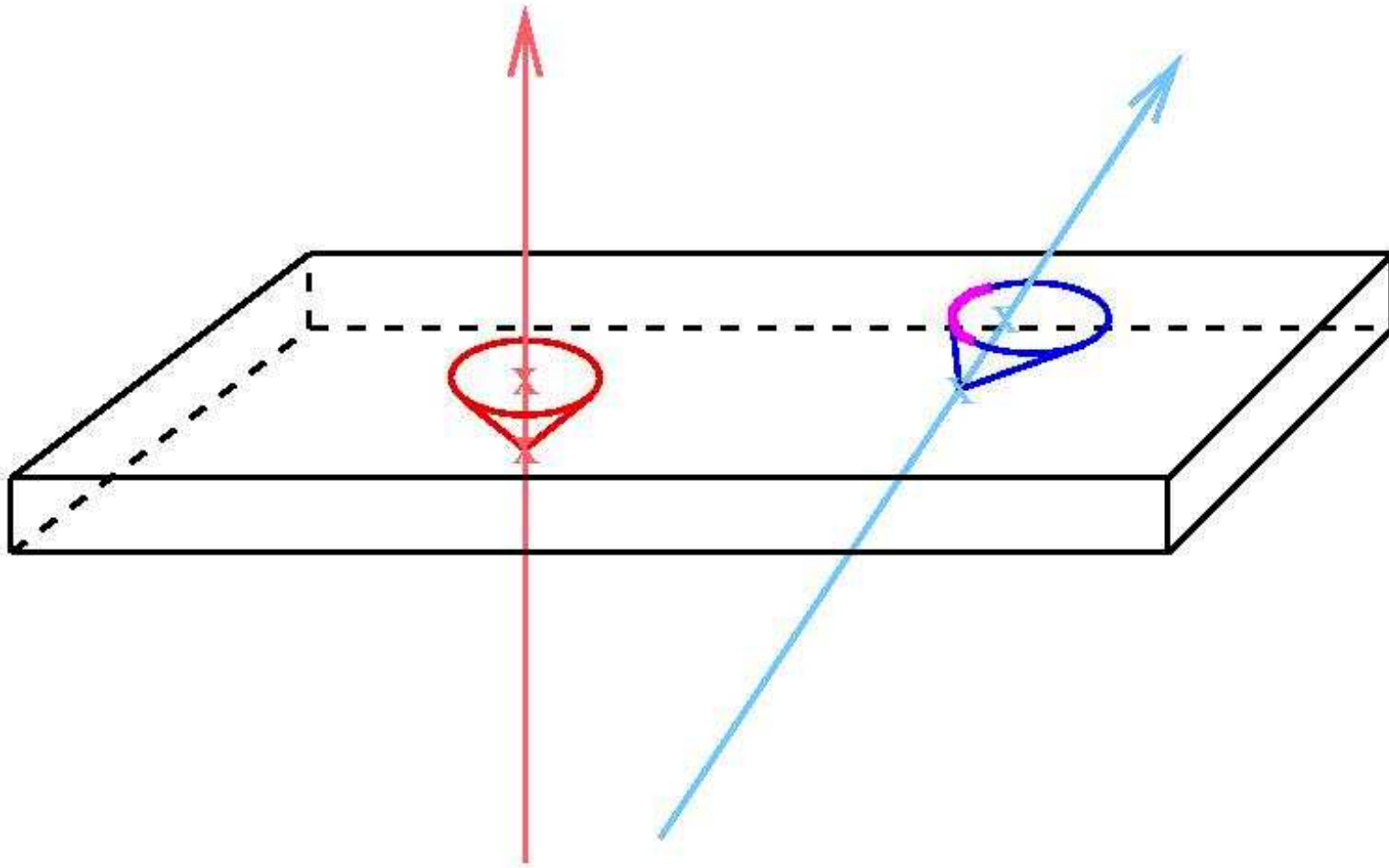
St. Gobain Spectrosil 2000

Increase in run time due to showering in detectors (simulation)



Relative experiment running time vs. quartz Cerenkov detector thickness

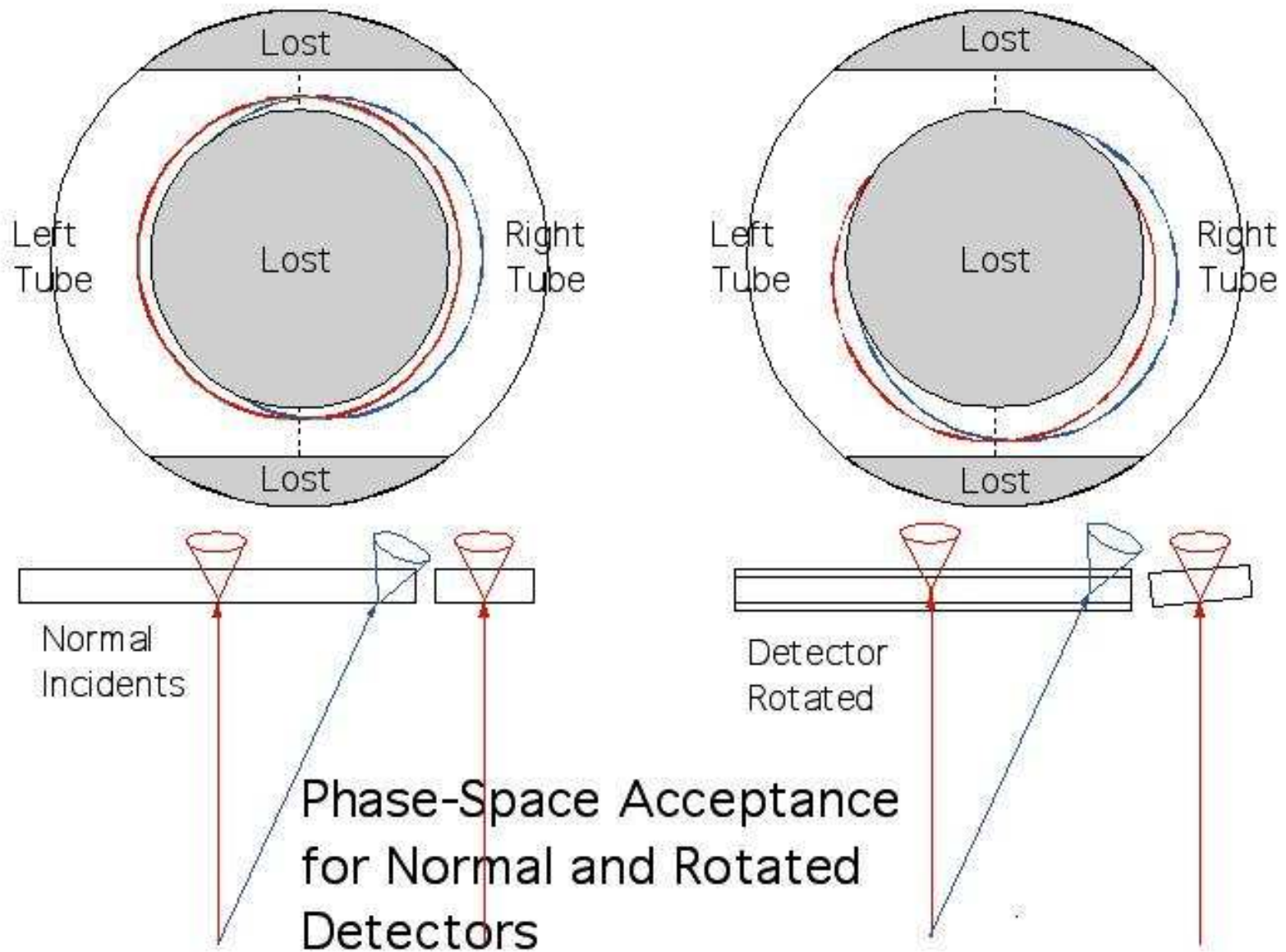
Acceptance of Cerenkov cone for total internal reflection



Normally incident electron - entire cone is internally reflected

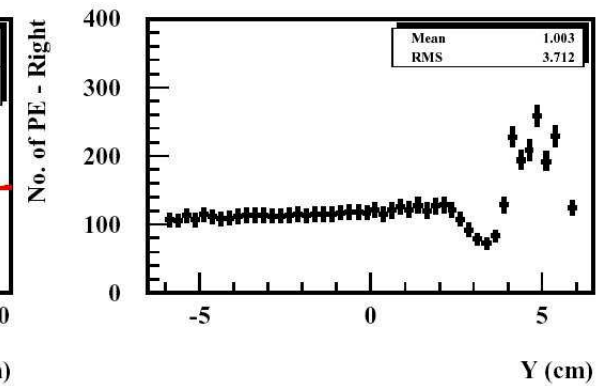
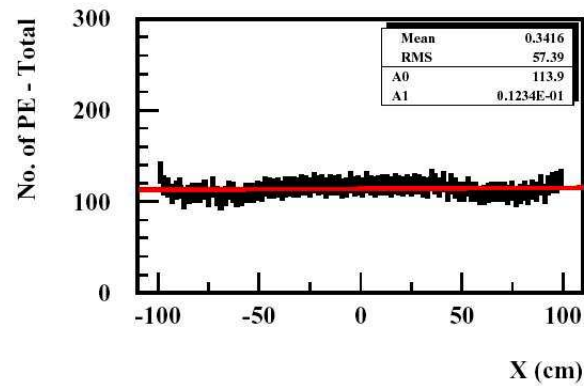
Electron incident at angle - **part of cone** is too steep

Rotation of detectors to increase light collection uniformity

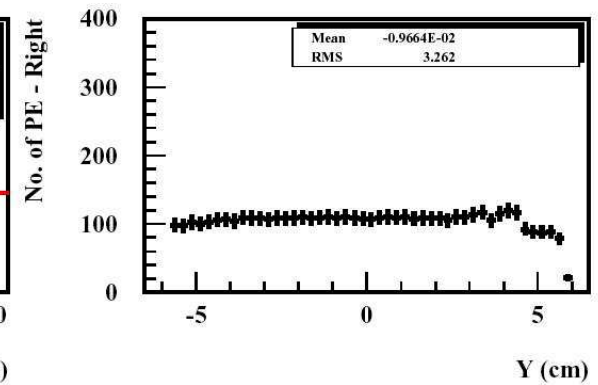
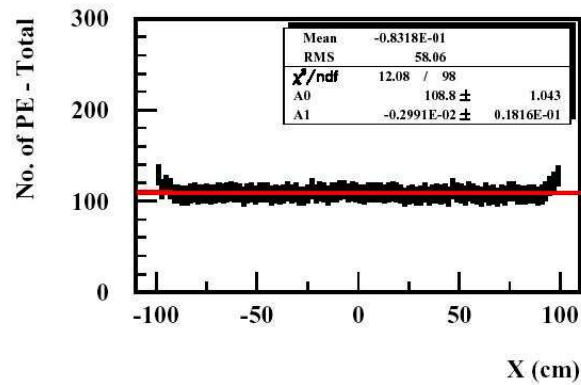


Simulation of improvement of uniformity in x & y

0° rotation



12.5° rotation



Photomultiplier tubes

130 mm diameter window (5 in.)

eight stages (for 10^3 gain with reasonable voltage per stage)

S20 photocathode: reasonable Q.E., low sheet resistivity

UVT glass front window

gettered (prevent photocathode poisoning)

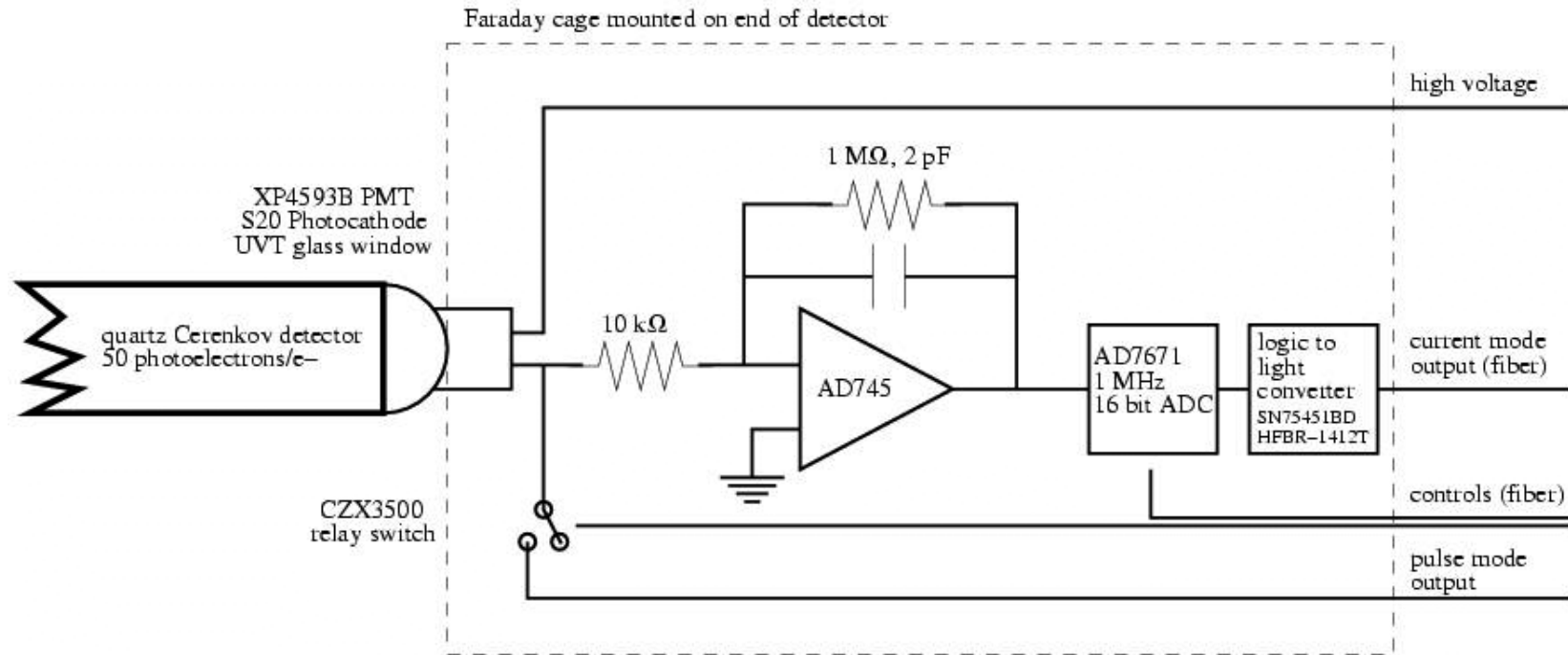
anode lifetime ~ 500 C (require $\times 10$ or more less)

linearity: specified 2% at 200 mA anode current

candidate tubes ordered from Photonis, delivery March 2003

--testing necessary

Front End Electronics



$50 \text{ photoelectrons/e-} \times 0.7 \text{ GHz} = 6 \text{ nA cathode current}$
run PMT at gain of 1000, then gain of 10^6 in low-noise amplifier = 6 V

- Normal operation in current mode
- Connection for auxiliary pulse mode (50 Ω cable, and turn up HV)
- Negligible pickup
 - Surrounded by Faraday cage
 - Only one ground to each package
 - Optically isolated from DAQ
- Low electronic noise contribution compared to counting statistics
- 1 MHz 16 bit ADC will allow for over sampling

Front End Electronics ADC



16-Bit, 1 MSPS CMOS ADC

AD7671*

FEATURES

Throughput:

1 MSPS (Warp Mode)

800 kSPS (Normal Mode)

INL: ± 2.5 LSB Max ($\pm 0.0038\%$ of Full Scale)

16-Bit Resolution with No Missing Codes

S/(N + D): 90 dB Typ @ 250 kHz

THD: -100 dB Typ @ 250 kHz

Analog Input Voltage Ranges:

Bipolar: ± 10 V, ± 5 V, ± 2.5 V

Unipolar: 0 V to 10 V, 0 V to 5 V, 0 V to 2.5 V

Both AC and DC Specifications

No Pipeline Delay

Parallel (8/16 Bits) and Serial 5 V/3 V Interface

SPI™/QSPI™/MICROWIRE™/DSP Compatible

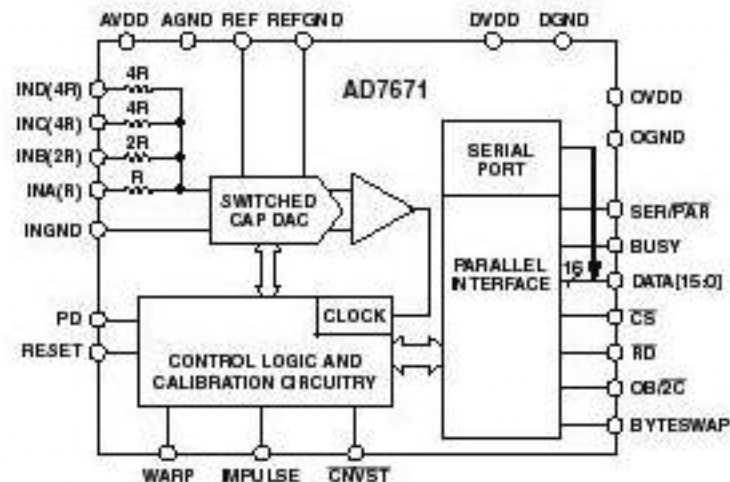
Single 5 V Supply Operation

Power Dissipation

112 mW Typical

15 μ W @ 100 SPS

FUNCTIONAL BLOCK DIAGRAM



Front End Electronics Amplifier



**Ultralow Noise,
High Speed, BiFET Op Amp**

AD745

FEATURES

ULTRALOW NOISE PERFORMANCE

2.9 nV/ $\sqrt{\text{Hz}}$ at 10 kHz

0.38 μV p-p, 0.1 Hz to 10 Hz

6.9 fA/ $\sqrt{\text{Hz}}$ Current Noise at 1 kHz

EXCELLENT AC PERFORMANCE

12.5 V/ μs Slew Rate

20 MHz Gain Bandwidth Product

THD = 0.0002% @ 1 kHz

Internally Compensated for Gains of +5 (or -4) or Greater

EXCELLENT DC PERFORMANCE

0.5 mV Max Offset Voltage

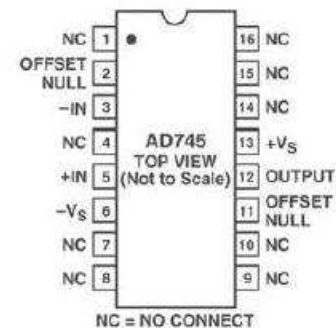
250 pA Max Input Bias Current

2000 V/mV Min Open Loop Gain

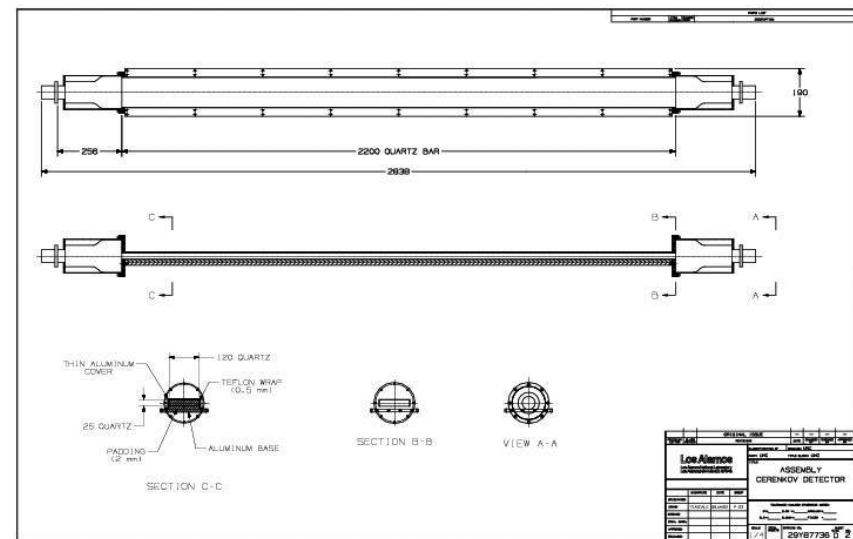
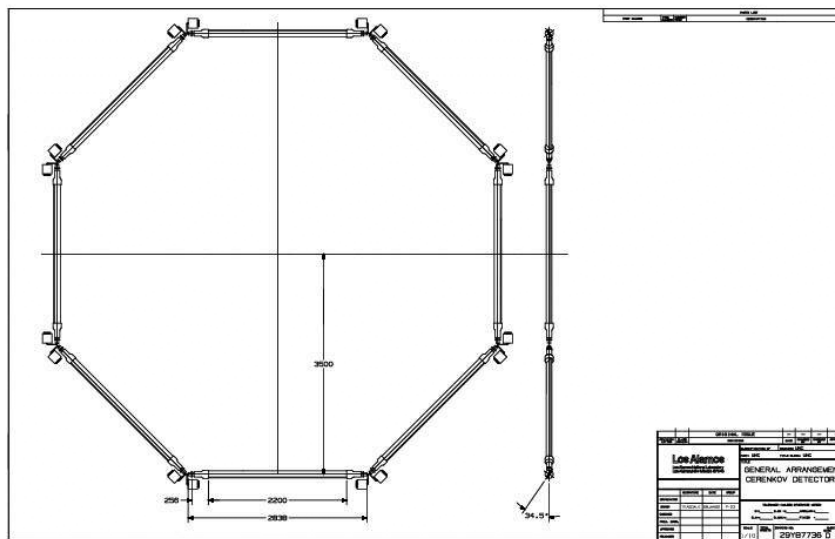
Available in Tape and Reel in Accordance with EIA-481A Standard

CONNECTION DIAGRAM

16-Lead SOIC (R) Package



Q_{weak} Detector System Design



preliminary design for support and housings

Q_{weak} Detector System

Status & Schedule of Hardware

Status:

Basic design exists, early 2003 construction of prototype and testing

Six 1 m long synthetic quartz bars ordered, delivery February 2003

Four candidate PMTs ordered, delivery February 2003

ADCs and evaluation board obtained

FEE- work remains on DSP/interface to DAQ

Schedule:

Detectors

2003	obtain PMTs and sample quartz design tests for quartz and PMT performance build prototype PMT bases
2004	perform test measurements for: light collection efficiency, linearity, radiation damage and PMT aging, PMT/quartz coupling
2005	finalize design, select mounting and shielding scheme, test with final electronics and configuration
2006	install detectors, run experiment

FEE

2003	obtain candidate ADCs, evaluation board, DSP develop design for pulse counting mode electronics build first generation prototype
2004	perform test measurements for noise levels, radiation damage build second generation prototype
2005	design finalized, assembly of final electronics test with final electronics and configuration
2006	install electronics, run experiment

Capital budget: \$600k, cost + contingency: \$825k